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A progress report

Direct Seeding of Pitch Pine in Southern New Jersey

by
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Not Enough Pine

THERE is not enough pine reproduction in the woodlands of southern New Jersey. This increasingly important problem, which plagues the state's Pine Region, is especially severe where seed sources for natural regeneration are poor. In some of these areas, pulpwood cuttings have removed all pines large enough to bear many cones. In other areas, wildfires have killed or damaged the seed source. If such sites are to support productive forest growth in the near future, more pine seedlings must be established through planting or direct seeding.

Planting has been tried extensively in the Pine Region, chiefly on state forests; but it has been unsatisfactory. Often less than half of the planted seedlings have lived. And many areas have been planted two or three times before they were adequately stocked.

Direct seeding of different species has often failed in many parts of the country. Nevertheless, recent research in the South and West indicates that, with proper methods, it can be successful and economically feasible. Direct seeding offers three advantages over planting: (1) the development of normal root systems without the damage incident to planting, (2) more natural selection among stems, and (3) possible reduction or elimination of loss from root rots. (Such losses have been high in the older New Jersey plantations.)

For these reasons, tests of direct-seeding pitch pine have recently been made in New Jersey.[1] The results are presented in this paper.

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[1]The aid of private owners in providing land and making machinery treatments is gratefully acknowledged. These owners are A. R. DeMarco, W. S. Haines, S. Lee, and J. J. Lee. Study plots on the DeMarco property were west of Chatsworth; those on the Haines land were near the Penn State Forest; and the ones on the Lees' property were near Speedwell.

Study Methods

1955 TEST

In 1955, four plots of 600 seed spots each were established in a 1954 wildfire burn. The areas had supported stands predominantly of pitch pine, with understories of bear oak and blackjack oak. The soil was classed as Lakewood. Between March 11 and 14, two of the four plots were cleared with a bulldozer and thoroughly disked (fig. 1); the other two were not treated. On March 29 and 30, about 15 seeds from the 1954 pine crop were sown at each spot. Cutting tests indicated that 78 percent of these seeds were sound.

Three methods of sowing seed and one of protecting seed were tried. Sowing methods were: (1) dropping seeds without covering, (2) dropping seeds and then covering them lightly with soil or duff, and (3) using the Baker automatic tree-seed planter.[2] Hardware-cloth cones were used to protect half of the spots from rodents and birds. Each cone, pushed about an inch into the soil, was held firmly in place by two wire pins.

Figure 1.--*Two views of one of the 1955 plots that were cleared with a bulldozer and disked before seed spots were sown. These plots were in an area burned by wildfire in July 1954.*

Above: the area shortly after seed was sown. Below: at the end of the first growing season; note the growth of bear oak sprouts.

1956 TEST

The 1956 test tried broadcast seeding vs. no seeding and these four methods of site treatment: (1) disking, (2) brush-hogging, (3) brush-hogging and disking, and (4) no treatment. The seeding, at a rate of 5 pounds per acre, was

[2]For a description of this planter, see Tackle, D. Comments on the Baker automatic tree seed planter. Jour. Forestry 52: 530-531. 1954.

done before site treatment. Seeding and most of the machinery treatments were completed on February 20. Seed was from the 1955 crop; in a 300-seed test, 58 percent germinated in 20 days.

For each of the 8 combinations of seeding and seedbed treatments, a 1/10-acre plot was established in each of 4 blocks. These blocks represented different conditions of ground cover and soil as follows:

- One block was on imperfectly drained Lakehurst soil in an area previously prescribe-burned and cut-over. It had scattered stems of pitch pine in the overstory, occasional sprouts of bear oak and other oaks in the understory. Most of the understory was in low shrubs such as staggerbush (Lyonia mariana), huckleberry (Gaylussacia sp.), and sand-myrtle (Leiophyllum buxifolium).

- A second block was on a dry upland Lakewood soil. Clumps of bear oak and blackjack oak with scattered stems of pitch pine dominated the vegetation. The forest floor was thin and scattered, except in clumps of shrubs.

- The third and fourth blocks were on an upland soil, once mapped as Sassafras gravelly sandy loam. Although there were a few scattered overstory pines, most of the cover was in thick clumps of oak sprouts, chiefly bear oak. The forest floor was almost continuous, much thicker than in the other blocks. The two blocks were nearly alike, except that the forest floor was thinner and the stems of the shrubby understory were smaller in one than in the other.

The thinner the forest floor, the better the seedbed conditions for pine-seed germination and initial seedling establishment. Thus conditions were comparatively favorable on the first two blocks, and unfavorable on the last two; one of the latter, having a perceptibly thicker forest floor, was more unfavorable than the other.

For each plot, estimates of germination and survival were obtained periodically from tallies of 24 milacre quadrats located along three permanently marked lines.

1957 TRIALS

One trial was a broadcast sowing of 1 acre with 2½ pounds of pitch pine seed, followed by brush-hogging, on February 8. This acre adjoined, and was comparable to, the 1956 plots on Lakewood soil. Seed was from the 1955 crop;

Figure 2.--*Brush-hogging one of the scrub oak areas where broadcast sowing of pitch pine seed was tried. The brush hog is like an oversize rotary lawnmower. This one had a 5-foot blade powered by a farm tractor. It easily handled clumps of scrub oaks 4 to 7 feet tall. Usually it severed them about 6 inches above the ground; but in this area, because of stumps, the blade was set a bit higher.*

a 300-seed sample showed 66 percent germination within 20 days in a 1957 test. A pound of this seed, sown in a nursery in 1957, produced 31,000 seedlings that survived the summer.

A second trial was a spot seeding on a dry upland site 6 miles northeast of the broadcast-seeded acre. The original sprout growth--pitch pine and scrub oaks, chiefly bear oak--had been poisoned. Some 520 spots were seeded, with 20 seeds at each, between February 14 and 27. This seed from the 1956 crop was 67 percent sound by cutting test. In all spots, seed was lightly covered with soil and protected with hardware-cloth cones.

Subsequent reproduction tallies were limited to 200 of the spots and to 80 milacre quadrats in the broadcast-seeded acre.

Results

1955 TEST

All treatments exerted significant effects. Disking, protection of spots by screening, and covering the seed all resulted in increased numbers of seedlings. Dropping and covering the seed by hand yielded more seedlings than placement with the Baker planter in disked plots, but not in undisked ones. The most effective combination--hand-covered seed in screened spots on disked ground--produced an average of 7.6 seedlings per spot in June 1955; this was some 63 times as many as started from uncovered, unprotected seed on undisked ground (table 1). In terms of stocked spots for the same two treatments, the respective figures were 92 percent and 7 percent (table 2).

Disking may have aided the establishment of pine seedlings in three ways:

- Blowing and washing of loose soil probably covered more seeds, at least where they were just dropped, than in the undisked plots.

- Losses from rodents and birds may have been reduced. Between seed sowing and germination, only six white-footed mice (Peromyscus leucopus) were caught in 480 trap-nights (120 in each plot); however, five of these mice were caught in undisked plots. And in the June 1955 tallies, evidence

Table 1.--Average number of seedlings per spot, by treatments

Seeding method	Disked		Undisked	
	Screened	Unscreened	Screened	Unscreened
	SEEDLINGS STARTING BY JUNE 1955			
Dropping	2.8	0.5	0.9	0.1
Dropping & covering	7.6	2.5	1.6	.6
Tree-seed planter	4.4	1.5	2.4	1.1
	SEEDLINGS LIVING IN NOVEMBER 1957			
Dropping	1.7	0.3	0.4	0.05
Dropping & covering	3.5	2.0	.7	.2
Tree-seed planter	2.2	.9	1.1	.6

Table 2.--Percentage of spots stocked with one or more seedlings

Seeding method	Disked		Undisked	
	Screened	Unscreened	Screened	Unscreened
		JUNE 1955[1]		
Dropping	60	26	30	7
Dropping & covering	92	53	40	25
Tree-seed planter	74	64	50	36
		NOVEMBER 1957		
Dropping	47	18	19	4
Dropping & covering	80	60	28	15
Tree-seed planter	54	48	31	24

[1]Includes all seedlings started by then, but not necessarily living at that time. The other figures are limited to seedlings living at the time of the tally.

of bird or rodent activity was found at several unprotected spots, again, mostly in the undisked plots.

- Competing vegetation was reduced. At the end of the first growing season, disked plots had 35 percent fewer scrub-oak sprout clumps than undisked plots. However, there still were about 1,200 clumps, totaling 12,000 stems per acre in the disked plots.

Dropping and covering seeds was the only seeding method that could be rated successful, and then only in the disked plots. There, spots that had been screened averaged 4 seedlings each at the end of the second growing season, with 82 percent of them stocked. Unscreened spots averaged 2.4 seedlings each, with 66 percent stocked.

Screening was highly important. In the first spring, 2 to 9 times as many seedlings started under the screens as in unprotected spots. Part of the difference may be due to preventing losses to birds and rodents; part, to the shading effect of the screens.

Probably because the seeds were not sown until late March, there was a noticeable amount of delayed germination. A few seedlings started after a rain in June 1955, a few more after rains in August, and still more in the spring of 1956. On some of the covered-seed treatments, spring

germination in 1956 averaged as much as 1.4 seedlings per spot.

The screens were removed in early May 1956, after much of the second-year germination had taken place; and this adversely affected survival. Within a month, 53 percent of these new seedlings in formerly protected spots had died, as compared to only 4 percent in unscreened spots.

However in certain treatments, the 1956 germination markedly increased the number of stocked spots. In late May 1956, two treatments had 22 and 32 percent more stocked spots than in September 1955.

Even though hand-covered seeds in protected spots on disked ground gave good results in this study, this method is too expensive to be practical. Moreover, it often provides too many seedlings in a small spot: in this test an average of 4 seedlings within a 4-inch radius. Yet this study did give some valuable leads:

- To obtain prompt germination and usually better survival, the seeding should be done before late March.

- Disking or other measures that remove the cover apparently reduce greatly the losses to birds and rodents.

- Disking after, rather than before, a broadcast seeding might be an effective procedure. Even though some seeds would be buried too deeply and the potential maximum number of seedlings would not be realized, still the percentage of quadrats stocked might not be much affected. Such was the inference drawn from quadrat tallies of natural seedlings (seed released from closed cones by the 1954 wildfire) on the disked and undisked plots. Stocked quadrats--66 percent in one instance--were essentially the same on comparable disked and undisked plots, but substantially fewer seedlings were present on the disked plots.

1956 TEST

Seeding, machine treatments, site, and seedbed conditions all affected the initial results. Seeding gave rise to many more seedlings than appeared as natural reproduction in unseeded plots. All machine treatments, as compared to no treatment, resulted in marked increases in both numbers of seedlings ($7\frac{1}{2}$ to 12 times as many in seeded plots) and percentage of stocked spots ($2\frac{1}{2}$ to 3 times as many in seeded plots) in June of the first year (tables 3 and 4). Stocking

Table 3.--Number of seedlings per acre as affected by direct seeding, brush-hogging, and disking[1]

Machinery treatment	Seeded plots	Plots not seeded
	IN JUNE 1956	
Brush-hogging and disking	12,722	819
Brush-hogging	10,850	308
Disking	8,107	275
None	1,074	64
	IN DECEMBER 1956	
Brush-hogging and disking	9,014	708
Brush-hogging	7,925	233
Disking	6,357	275
None	647	43
	IN NOVEMBER 1957	
Brush-hogging and disking	2,639	181
Brush-hogging	1,992	100
Disking	1,107	98
None	243	28

[1]Values given are averages for the treatments actually made. Unfortunately not all the scheduled disking was completed.

the first spring varied widely among the four site and associated seedbed conditions. This is illustrated in the following tabulation for one treatment--seeding and brush-hogging--as of June 1956:

Site	Type of seedbed	Seedlings per acre[3] (number)	Quadrats stocked (percent)
Imperfectly drained	Favorable	25,917	100
Well drained:			
Lakewood	Favorable	10,375	94
Sassafras	Unfavorable	6,458	88
Sassafras	Very unfavorable	1,125	38

[3]If amounts of natural reproduction in the unseeded but brush-hogged plot of the same block are subtracted, the values are 25,709, 9,917, 6,167 and 1,000.

Table 4.--Percentage of milacre quadrats stocked with one or more seedlings, as affected by direct seeding, brush-hogging, and disking[1]

Machinery treatment	Seeded plots	Plots not seeded
	IN JUNE 1956	
Brush-hogging and disking	93	46
Brush-hogging	82	22
Disking	89	18
None	32	5
	IN DECEMBER 1956	
Brush-hogging and disking	92	46
Brush-hogging	81	18
Disking	82	18
None	21	4
	IN NOVEMBER 1957	
Brush-hogging and disking	76	18
Brush-hogging	57	9
Disking	46	8
None	14	2

[1]Values given are averages for the treatments actually made. Unfortunately not all the scheduled disking was completed.

Although brush-hogging and disking resulted in the highest average catch of seedlings (table 3), there was a marked interaction with seedbed conditions. For instance, in June 1956, on one block with little forest floor (favorable seedbed), disking after brush-hogging resulted in 2,700 fewer seedlings per acre than brush-hogging alone, apparently because many seeds were buried too deeply in the forest floor or soil. But on a block with thick forest floor (unfavorable), the same treatment resulted in 3,700 more seedlings per acre, apparently because any losses from seed burial were more than offset by the favorable effects of chopping up the litter and bringing seeds into contact with mineral soil.

Second-year results were greatly affected by the 1957 drought. During the 5-month period from May to September rainfall at the Lebanon Experimental Forest (6 to 12 miles from the plots) was 8.98 inches, compared to 18.86 inches in the same period in 1956 and the normal amount of 21 inches.

Of the seedlings living in the fall of 1956, 74 percent were dead by the fall of 1957.

Mortality varied with site. The highest losses, 81 percent, occurred on the two sandier sites--the excessively drained Lakewood soil and the imperfectly drained Lakehurst soil. The latter had been moist enough in 1956 to provide the best conditions for germination and initial establishment, but became so dry in 1957 that seedlings 4 inches tall died. The lowest mortality, 55 percent, was on the slightly heavier Sassafras soil, despite the presence of more competing vegetation than on the sandier sites.

1957 TRIALS

Unusually dry weather in May and June provided unfavorable conditions for seed germination and seedling establishment. At the Lebanon Experimental Forest, rainfall in May was 1.15 inches and in June 1.89 inches. These amounts were, respectively, 2.8 and 2.0 inches less than normal.

On the broadcast-seeded acre, only one living seedling was found in the 80 milacre quadrats in July, none in September. No other dead seedlings were found.

In contrast, 64 percent of the seed spots were stocked with living seedlings in early July. And in an additional 10 percent of the spots, seedlings had started only to die. The average spot had 2.3 living seedlings. Since seedbed conditions here were comparable to those of the 1955 undisked plots, it was surprising that the 1957 results were substantially better: 74 percent of the spots initially stocked as compared to 40 percent in the more favorable spring of 1955.

Even with the exceptionally dry summer, the observed mortality of all seedlings starting in the 1957 spots was only 37 percent in September, as compared to 55 percent first-summer mortality in similarly treated spots in 1955. Fifty-five percent of the 1957 spots had living seedlings in September--almost twice the stocking obtained in similar spots in 1955.

Just why germination and first-summer survival were so good in the 1957 seed spots is not known. Possibly these spots received some rain in local showers that did not fall on the 1957 broadcast seeding 6 miles away. Even if true, however, this would not explain why results in the 1957 spots were better than in similar spots in 1955.

Discussion of Results

While results to date do not warrant specific recommendations, they do indicate that direct seeding can provide adequate amounts of pine reproduction under certain conditions. These include (1) sufficient sound seed, sown preferably in January or February; (2) favorable seedbed; (3) light cover of soil or debris over the seed; (4) sufficient protection from rodents and birds; and (5) favorable weather for at least two growing seasons.

These conditions, other than favorable weather, can largely be met by disking the site, sowing and lightly covering about 12 sound seeds per spot, and then protecting each spot with a hardware-cloth cone for a year. In the 1955 test, these treatments resulted in 80 percent of the spots being stocked with living seedlings at the end of the third growing season. Omitting even one of the treatments appreciably lowered the catch. However, in the dry summer of 1957, this combination without disking resulted in 55 percent of the spots being stocked in September.

For practicality and better distribution of seedlings, broadcast sowing of seed followed by mechanical site treatment seems far more advantageous than seed spots. Usually, if the litter mat of the forest floor is relatively thick and continuous, the area should be prescribe-burned before seeding. Of the mechanical treatments, brush-hogging is apparently preferable to disking. The brush hog not only clips back competing shrubs and small trees, but scatters the forest floor and chips, thus lightly covering much of the seed. Cost of brush-hogging should not be excessive since in our trials one man, operating a farm tractor and attached brush hog, covered an acre in about $1\frac{1}{2}$ hours.

Results from the 1956 study indicate the futility of broadcast seeding, even when followed by brush-hogging, where the seedbed consists of thick, unbroken forest floor. But where the forest floor is somewhat thinner, disking after seeding and brush-hogging is an alternative to previous prescribed burning. Such disking increased the initial establishment of pine seedlings in both blocks on Sassafras soil. However, only in the block with the thinner forest floor did this combination of treatments provide as many seedlings as started after seeding and brush-hogging on a favorable seedbed.

Seed may be the most expensive item. In the 1956

test, seed was sown at the rate of 5 pounds per acre. When purchased from dealers, pitch pine seed may cost $ 7 per pound. However, local supplies are much cheaper. In addition, under normal weather conditions one pound of seed (70 percent sound) per acre on imperfectly drained sites, or 2 pounds on dry sites, may be sufficient when sown in the winter just before brush-hogging. On the basis of 1956 results, these amounts would provide 2,800 to 3,800 living seedlings per acre at the end of the first growing season. Normally such numbers are more than sufficient for restocking open areas.

Weather, of course, is a controlling factor. That alone may account for the failure so far of the 1957 broadcast seeding. (Perhaps some of those seeds will germinate in 1958). However, we rarely have years like 1957, with less than half the normal rainfall during the growing season. The fairly good results in 1956, when growing-season rainfall was 10 percent less than normal, indicate that broadcast seeding followed by brush-hogging would usually succeed except when summer droughts of marked severity occur.

Summary

In a 1955 study of 2,400 seeded spots, results in undisked plots were unsatisfactory. But in disked plots, 12 lightly covered sound seeds of pitch pine per spot gave good results. Where seeds were protected by hardware-cloth cones 82 percent of the spots had living seedlings at the end of the first growing season, 80 percent at the end of the third growing season. Where seeds were not protected, corresponding values were 40 percent and 60 percent. (The increase after first year was due to delayed germination).

In 1957, when 13 sound seeds of pitch pine per spot were sown, covered, and protected in an undisked area, seedlings started in 74 percent of the spots. In September, 55 percent had living seedlings. All things considered, spot seeding seems a rather impractical procedure.

Broadcast seeding tests were started in 1956 using tractor-drawn machinery to cover seed and cut back competing vegetation. A brush hog proved superior to a farm disk. On favorable seedbeds, the broadcast sowing of 5 pounds of pitch pine seed per acre and subsequent brush-hogging produced about 26,000 seedlings per acre on an imperfectly

drained site and 10,000 per acre on a well-drained site in June of the first growing season. But in the drought year of 1957, as many as 81 percent of the seedlings that had lived through the summer of 1956 then died, and practically no seedlings started in a 1-acre 1957 test of broadcast seeding and brush-hogging.

However, 1957 was so exceptionally dry that further trials of broadcast seeding and brush-hogging seem warranted.

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